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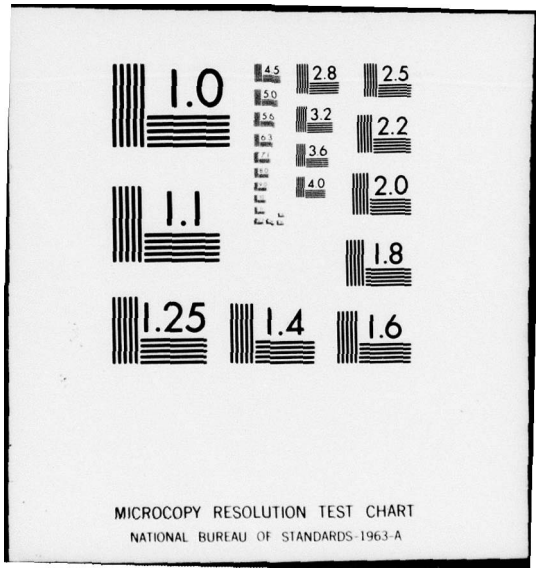
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OBSERVATIONS ON EUROPEAN LOW-TEMPERATURE PHYSICS RESEARCH: AN ANNOTATED DIRECTORY OF LOW-TEMPERATURE PHYSICS IN BRITISH UNIVERSITIES AND SOME COMMENTS ON THE LOW TEMPERATURE PHYSICS PROGRAMS IN EUROPE

DR. THOMAS A. KITCHENS

28 DECEMBER 1976

UNITED STATES OF AMERICA

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This report summarizes the author's observations on low-temperature physics research in Europe during the period of August 1975-August 1976. It features an annotated directory of low temperature research in British Universities, and contains comments on visits to Continental institutions, both of which supplement ONRL Report D-15:1973 "Directory of European Low Temperature Research" by E. Edelsack *et al.* Emphasis in the comments is on refrigeration and low temperature components rather than on superconductivity.

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This is a summary document of my encounters with research in low-temperature physics in Europe between August 1975 and September 1976. Much of the commentary has already been published as articles in the *European Scientific Notes*, or as *ONRL Reports*, but some is drawn from unpublished trip reports and a modicum is new.

Section I. This is an annotated directory of Low Temperature Research in British Universities which, to some extent, supplements the "Directory of European Low Temperature Research" by E. Edelsack and co-authors in 1973 (see ONRL D-16:73). The basis of this new directory is "Research Fields in Physics," the 1976 edition of a directory published by the British Institute of Physics. I have brought this information up-to-date to the best of my knowledge, but in many cases I have not visited the institution and have little or no personal knowledge of the program there. It covers only research within academia, and does not include the many non-academic research programs which now utilize low temperatures to study phenomena that also occur at higher temperatures. In this way, many physicists who would call themselves low-temperature physicists have been excluded. On the other hand, when a group has been included, I have tried to indicate the breadth of their program by mentioning the non-cryogenic parts as well.

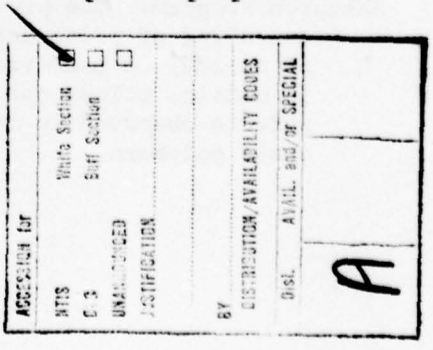
I have perhaps erred by omitting many theoretical groups whose work impinges on low-temperature physics. Since most solid-state theory does, I would have had to include all solid-state theoretical groups which would have more than doubled the directory. Therefore, I have included only those who specialize specifically in low-temperature phenomena.

ABERDEEN UNIVERSITY

Department of Natural Philosophy
Dr. R.C. Clark
Research Program: Theory of ions in and surfaces on He^3, He^4 and isotopic solutions.

UNIVERSITY OF ASHTON, BIRMINGHAM

Department of Physics
Staff: Drs. W.E.J. Neal and R.W. Fane
Research Program: The study of electrical and optical properties of metal and thin films.



UNIVERSITY OF CAMBRIDGE

Department of Engineering
Professor A.H. Beck
Research Program: The study of microwave devices utilizing superconducting solenoids and active elements composed of superconducting films.
Department of Metallurgy and Materials Science
Drs. A.M. Campbell and J.E. Evetts
Research Program: The study of the technical superconducting properties, such as flux pinning of alloys and intermetallic compounds.
Department of Physics
Director/Group Leader: Prof. D. Shoenberg, Prof. Sir Brian Pippard, Dr. C.J. Adkins, Dr. J.R. Waldram, Dr. W.A. Phillips
Research Program: Low temperature physics, electrical, magnetic and thermal properties of metals, including superconductivity; amorphous conductors.
Theoretical Director/Group Leader: Dr. V. Heine, Prof. Sir Samuel Edwards (on leave to direct the Science Research Council), Prof. B.D. Josephson, Dr. J. Inkson
Research Program: Theory of the electronic, magnetic and structural properties of metals; covalent bonding, surface physics including theory of low energy diffraction, superconductivity, many-body problems.

UNIVERSITY OF BIRMINGHAM

Department of Physics
Group Leader: Prof. W.F. Vinen, Dr. N. Berovic, Dr. P.H. Borcherds, Dr. E.M. Forgan, Dr. C.E. Gough, Dr. J.M. Lumley, Dr. P.G. Mattocks, Dr. C.M. Muirhead, Mr. S. Nedjat, Dr. R.W. Whitworth, Dr. R.C. Young
Research Program: The current experimental research program includes:
(a) the use of light scattering in the study of superfluid helium, of quantum solids (^{4}He and ^{3}He), and of disordered solids;
(b) the study of the electronic structure and properties of type II superconductors and of metallic layer compounds such as NbS_2; and
(c) the study of Fermi surface electronic structure of the rare earth metals.

UNIVERSITY OF BRISTOL

Department of Physics
Group Leader: Prof. R.G. Chambers
Research Program: The program includes work on the following topics: annealing of point defects in alkali metals; thermal expansion of solids; de Haas-van Alphen effect and magneto-optical effects in metals, alloys and semi-metals; various other high-frequency effects observed in magnetic fields; superconductivity of inorganic polymers.

Department of Physical Chemistry
Professor D.H. Everett
Research Program: The study of heat capacities and thermal conductivities of disordered solids between 1.3 and 30 K.

BRUNEL UNIVERSITY, UXBRIDGE

Department of Physics
Mr. R.H. Creamer
Research Program: The study of nucleate boiling in liquid helium.

UNIVERSITY OF EAST ANGLIA

School of Mathematics and Physics
Director/Group Leader: Prof. D.V. Osborne, Dr. C.C. Matheson, Dr. G. Turner, & Dr. B.R. Watts
Research Program: Phonon propagation in solids and in liquid helium, hydrodynamics and heat transfer in liquid helium; unusual aspects of superfluid helium film transfer studied by ellipsometric and other techniques; measurement, by means of the de Haas-van Alphen effect in metals, of (i) the effect of strain on the properties of conduction electrons, (ii) the Fermi surface of chromium, and (iii) the scattering of conduction electrons by dislocations; studies of the generation of acoustic waves by direct interaction with electromagnetic waves. Available facilities include high magnetic fields (to 10 T), ^{3}H cryostats, and a ^{3}H - ^{4}H dilution refrigerator.

UNIVERSITY OF EDINBURGH

Department of Physics
Staff: Prof. W.Cochran, Prof. R.A. Cowley, Dr. G.S. Pawley, Dr. H. Montgomery, Dr. W. Taylor
Research Program: The program is largely concerned with the structural arrangement and motion of atoms and molecules in crystalline solids, and in particular the changes which take place when solid state phase transitions occur. Recent work has mainly been on phase transitions in ferroelectric crystals, and plastic crystals (in which there is molecular rotation above the transition temperature).

UNIVERSITY OF ESSEX

Department of Physics
Drs. L. Mackinnon, D.R. Tilley and J.Tilley
Research Program: Ultrasonic techniques are used in studies both of superconductivity work is a study of thin films by using acoustic surface waves. In normal metals, the quantum oscillations in ultrasonic oscillations are also being studied. The equipment

includes a superconducting solenoid capable of fields up to 9 T, a 22-inch Varian electromagnet, and a ^{3}He - ^{4}He dilution refrigerator.

UNIVERSITY OF HULL

Department of Applied Physics

Dr. S.B. Palmer, Dr. R.D. Greenough

Research Program: Measurements of the velocity of sound elastic constants, ultrasonic attenuation, and thermal and magnetostrictive strains in various materials. Studies of magnetostrictive and elastic constants of single crystal rare earth elements and binary intro-rare earth alloys are being made in the temperature range $4<T<300$ K. The elastic constant measurements yield information on acoustic soft mode behavior in these materials, and coupled with ultrasonic attenuation studies they are revealing the presence of antiferromagnetic domains in the helical regime. Currently they are interested in impurity levels in the rare earths, and acoustic studies are being used to investigate the effects of impurities on physical properties. The isotopic mass dependence of the velocity of sound in liquids is being studied in normal liquids using neon.

UNIVERSITY OF KENT

Department of Physics

Group Leader: Prof. J.B. Brown, Dr. S.J. Rogers, Dr. M.R. Halse, and Dr. W.A.B. Evans

Research Program: Bernoulli and Hall potentials are being investigated in Type I superconductors and a study is being made of the effect of thermal fluctuations at 4 K on certain types of Josephson junction. The properties of the superfluid helium film are being measured by a quartz crystal method. Heat pulses with fast thin-film detectors are used to study pure dielectric crystals down to 0.3 K. The theory of quantum fluids is being investigated.

UNIVERSITY OF LANCASTER

Department of Physics

Dr. A.M. Guénault, Dr. P.V.E. McClintock, Dr. D.J. Meredith, Dr. G.R. Pickett, Dr. J.K. Wigmore

Research Program: The group is concerned with electrons and phonons and their interactions in metals and other solids, and with the properties of liquid ^{3}He and ^{4}He. Extensive low temperature facilities are available, and the department runs its own helium liquefier. Coherent phonons at microwave frequencies are used to study the electronic properties of superconducting and normal metals. A technique using the direct coupling between electromagnetic

and acoustic waves is being developed for the transducerless generation and detection of ultrasound at frequencies up to 35 GHz. The propagation of very high-frequency phonons in solids is also being studied by means of heat pulses and by bolometric detection of 35-GHz ultrasound. Experiments are in progress on the interaction of these phonons with thermally excited phonons in dielectrics, with spins and impurities in magnetic materials and with electrons in metals. The transport properties of metals and alloys are being studied over a wide temperature range (0.1-300 K). The electrical and thermal resistivities, and in particular the thermoelectric power, give information about the dynamic properties of electrons and phonons and about the precise nature of their scattering processes in solids. Current experiments involve the use of SQUIDs to study thermoelectric effects in superconductors. The properties of liquid helium are elucidated through studies of the motion of ions. Experiments in progress include an investigation of roton creation by ions travelling at the critical velocity through superfluid ^{4}He, and measurements of ionic mobilities in highly degenerate ^{3}He. A number of experiments are being performed at ultra low temperatures using dilution refrigerators and additional paramagnetic cooling where needed. These include: calorimetric studies of nuclear hyperfine interactions, nuclear magnetic resonance using a novel SQUID technique, ion motion in the newly discovered phases of ^{3}He below 2 mK.

On 28 May 1976 I visited the Low Temperature Physics Group at the University of Lancaster. I discussed the Group's plans for millidegree work with Drs. A. Guénault, Peter McClintock, and David Meredith and some theoretical aspects of transverse zero sound with Dr. Bolton, a postdoctoral research associate. Dr. G.R. Pickett is presently at the H.C. Ørsted Institute in Copenhagen. Perhaps the most impressive work I saw was Peter McClintock's recently completed negative-ion mobility studies. He has succeeded in observing the shedding of vortex rings by negative ions at 25 bar in He II near 1 K and has evidence suggesting rotons are created in pairs by negative ions for T = 0.45 K at 25 bar in He II. See ESN 30-2:86 and 30-7:326 (1976) for a more detailed account of the program.

Theory Group Leader: Prof. W.M. Fairbairn, Dr. P.M. Lee, Dr. R.J. Watts-Tobin

Research Program: Many of the problems under investigation involve applications of theoretical techniques which have been developed to deal with the many-body problem. The mixed state of Type II superconductors involves the solution of quantum-mechanical equations describing the electrons in the presence of a very inhomogeneous magnetic field. The formulation of equations to calculate experimental properties requires many-body theory, and solving them is a computing problem. Work is in progress

on a joint project with the Institut für Festkörperforschung of the Kernforschungsanlage, Jülich, to compute transport properties of the mixed state. The flux-flow resistivity in which the mixed state structure moves through the superconductor is particularly interesting. There are also studies on ordering phenomena. The magnetic structures of rare earth metals are being considered using basic interactions, including RKKY, for the forces between the constituent ions. Investigation is being undertaken of the order-disorder and lattice-structure transitions which occur in solid hydrogen at low temperatures. The recently discovered phases of ^{3}He present a fascinating problem, and investigations are proceeding into the many interesting theoretical aspects of this low temperature phenomenon. Many-body and self-consistent effects are also being included in calculations on charge distributions near surfaces and interfaces, and of the energy distribution of electrons produced in field emission.

UNIVERSITY OF LEEDS

Department of Physics

Group Leader: Prof. J. S. Dugdale, Dr. D. Greig, Dr. D.E. Moody

Research Program: The main objective is the interpretation of the transport and magnetic properties of a wide range of metals and alloys in terms of their basic electronic structures, in particular alloys based on iron, nickel, palladium and platinum and sigma phase alloys. Techniques include the measurement of specific heat, susceptibility, magnetization, and electrical and thermal transport properties; neutron scattering and Mössbauer effect. Intensive studies are being made of the variation of the relaxation times of the conduction electrons over the Fermi surface in alkali and noble metals and alloys. The techniques used here include the de Haas-van Alphen and RF size effects, and measurements of the Hall coefficient, magnetoresistance and thermoelectric power. Investigations of the variation of relaxation times under pressure are being made. Work is also being undertaken to measure the thermal conductivity of polymers and glasses at temperatures.

On 5 July 1976, I visited the physics group at the University of Leeds who are interested in the electronic properties of solid state matter. (This constitutes about a quarter of the Physics Department, and a second quarter is involved in polymer physics with Prof. I. Ward, the Chairman of the Physics Department being the prime mover.) Dugdale and his students are studying the de-Haas-van Alphen oscillations in Rb-doped single-crystal sodium.

I spoke to Greig about his transport phenomena investigations. In connection with the polymer physics group at Leeds he has made some

interesting thermal conductivity measurements on extruded polyethylene and semicrystalline polyethylene terephthalate [*J. Phys.* C 8 1637 (1975) and *J. Phys.* C 8, 3121 (1975), respectively]. The second are consistent with W. Little's theory of acoustic mismatch [*Can. J. Phys.* 37, 334 (1959)] while the first shows an anisotropy due to crystallite allignment for which no theory has yet been properly developed. Greig is also looking again at the high temperature resistance minimum in $Pd_{60}Ag_{40}$ [see *Phys. Rev. Lett.* 32, 833 (1974)] due to some conflicting data from S. Arajs at Clarkson Polytechnic, Pottsdam, New York. It appears that the minimum may be very sensitive to composition and possibly to the thermal history.

UNIVERSITY OF LONDON: BEDFORD COLLEGE

Department of Physics

Senior Staff: Prof. E.R. Dobbs, Dr. M.J. Lea

Research Program: The properties of liquid ^3He at millikelvin temperatures are studied in a dilution refrigerator with microwave ultrasonics. This is being extended below 3 mK in a study of the new phases of ^3He. London penetration depths are being measured in superconducting crystals by using the electromagnetic detection of shear waves at MHz and GHz frequencies.

I have visited the group at Bedford, several times during the academic year 1975-76 and know that they would like to work on the superfluid phases of ^3He and have made proposals to the Science Research Council. The SRC has suggested that Bedford collaborate with the University of Sussex group. In late July I heard that the group had begun an active collaboration and had contributed some monetary support to the Sussex effort and that Dr. Lea will spend some time at Sussex this coming year. For a touch of detail on their program see ESN 30-7:326 (1976).

UNIVERSITY OF LONDON: IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Group Leader: Prof. B.R. Coles, Dr. J.G. Park, Mr. D. Caplin, Mr. B. Rainford, and Mr. N. Rivier.

Research Program: The investigation of the static and dynamic properties of magnetic systems and superconductors. For a more detailed account of the SQUID work by J.G. Park see ESN 30-2:86 (1976). I spent some time personally with J.G. Park working on the utilization of SQUIDs in calorimetry, and with Coles, who was chairman of the SRC Physics committee in 1975-76.

UNIVERSITY OF LONDON: QUEEN MARY COLLEGE

Dr. D.N. Batchelder

Research Program: Polymer and noble gas crystals: measurement of phonon dispersion, elastic constants, thermal conductivity and adsorption spectrum as functions of temperature (1-200 K) and pressure (0-10 kbar).

UNIVERSITY OF MANCHESTER

Department of Physics
Director: Prof. H.E. Hall, Dr. D. St.P. Bunbury, Dr. M.A.H. McCausland, Dr. D.J. Sandiford
Research Program: The two main programs are the study of superfluids and of magnetically ordered systems. Mechanical properties of the superfluid phases of ^{3}He are being studied down to 2 mK, and the critical behavior of transport properties of ^{3}He-^{4}He solutions is being investigated near the λ-line and tricritical point. Hyperfine interactions in magnetically ordered systems, mainly rare earth metals and alloys, are being studied by the Mössbauer effect and by fast-spin echo nuclear resonance spectroscopy.

I visited the University of Manchester in late January 1976--just after the very low temperature group there, primarily Hall and Sandiford, had been advised that their proposal to the SRC to study the thermomechanical properties of the new superfluid phases of ^{3}He had been funded for the first year at the level of £70,000. Their approach is to be rather conservative and use tried methods in the refrigeration, i.e., commercially available dilution refrigeration and a copper nuclear adiabatic demagnetization stage. They will be purchasing the dilution referigerator, probably from SHE, Inc., and the adiabatic magnet, and build only a minimum of the equipment. The group at Lancaster, especially Dr. G. Pickett, will be collaborating and providing the SQUID knowledge.

UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY

Department of Pure and Applied Physics
Group Leader: Professor E.H. Rhoderick,Professor A.C. Rose-Innes, Dr. J. Lowell
Research Program: The physics of electrons in solids, especially those aspects relevant to solid state electronic devices, e.g., semiconductors and metals, superconducivity, properties of new semiconducting materials. Contact electrification of solids. Scanning electron microscopy and Auger spectroscopy. (Note: The Solid State Electronics Group is situated in the Department of Electrical Engineering and Electronics.)

UNIVERSITY OF NOTTINGHAM

Department of Physics
Theoretical Staff: Prof. K.W.H. Stevens, Dr. C.A.Bates, Dr. F.W. Sheard, Dr. G.A. noombs, Dr. J.R. Fletcher, Dr. R.M. Bowley
Research Program: The study of magnetic ions and their interaction with lattice vibrations including the Jahn-Teller effect, spin-lattice relaxation, phonon scattering and nonlinearacoustic propagation. Exchange interactions in magnetic insulators and

optical spectra. Fluctuating valency in rare earths. The properties of liquid metals and the theory of quasi-one-dimensional metals. The theory of ultrasonic attenuation in solids and liquid helium, acoustic surface waves, theory of thermal expansion and thermal conduction including heat transfer across interfaces and the Kapitza resistance. The properties of excitations and themobility of ions in liquid ^{3}He, ^{4}He and in the various phases of superfluid ^{3}He.

Experimental Staff: Prof. L.J. Challis, Dr. J.C. Matthews, Dr. A.F.G. Wyatt, Dr. O.H. Hughes, Dr. V.W. Rampton, Dr. R.J. King, Dr. J.M. Chamberlain, Dr. L. Eaves and Dr. A.M. de Goer

Research Program:

(a) Phonons. The work covers a range of topics, and the techniques include piezoelectric generation of phonons (10^8-10^{10} Hz), thermal generation of phonons (thermal conductivity and heat pulse; 10^9-10^{12} Hz). Investigations are being made of attenuation and dispersion by intrinsic processes in solids and liquid He II (down to 50 mK), transmission across boundaries between solids and liquid helium (Kapitza conductance), surface waves, and phonon spectroscopy.

(b) Metals. The work here includes calorimetric measurement of specific heats of metals and alloys of transition metals (and also of paramagnetic crystals) and electron tunnelling through barriers doped with magnetic impurities. Measurements can be made from approximately 50 mK upwards and in high fields. The Department has three dilution refrigerators. For a more detailed account of the research program see ESN 29-12:543 or *ONRL Report* C-23-75.

UNIVERSITY OF OXFORD

Department of Engineering Science

Dr. C.A. Bailey, Dr. H. Sixsmith, Dr. G. Davey, Mr. B.A. Hands, Mr. W.B. Bald

Research Program: Fluid Flow and Heat Transfer. Nucleate pool boiling (N_2, H_2, He), heat transfer and pressure drop in two phase flow (N_2, He), flow instabilities (N_2, He); theoretical and experimental study of flow and heat transfer in a rotating reference frame. Development of components for refrigerators and liquefiers. Computer programs for thermophysical properties of cryogenic fluids.

Inorganic Chemistry Laboratory

Dr. L.A.K. Staveley

Research Program: Thermodynamic studies of order-disorder phenomena in crystals, involving calorimetry from 2 K to 500 K, solution calorimetry, EMF measurements, etc. Excess functions of binary condensed gas mixtures, including measurements to 1000 atm.

Department of Physics, Clarendon Laboratory

Drs. D.M.S. Bagguley, J.M. Baker, R. Berman, A.H. Cooke, A.J. Croft, D.T. Edmonds, G. Garton, J. Hatton, W. Hayes, R.W. Hill, J.W. Hodby, D.A. Hukin, M.J.M. Leask, J. Owen, H.M. Rosenberg, N.J. Stone, R.A. Stradling, J. Wilks

Research Program: The research program covers a very wide field, from thermal, electrical and magnetic experiments at temperatures down to 10^{-4} K to the physics of the wear of machine tools and the chemistry of crystal growth above 1000 K. Many experiments require high magnetic fields; the facilities of the Mullard Cryomagnetic Laboratory include both superconducting magnets and large solenoids giving fields up to 16 T. A number of projects give scope for considerable theoretical work, especially those using spectroscopic techniques, which cover the frequency range from 10^{6} Hz to 10^{15} Hz. Magnetic and electric properties are intensively studied in metals, semiconductors, and insulators using methods as diverse as nuclear orientation, high resolution optical spectroscopy, synchrotron radiation, ultrasonics at 10^{10} Hz, cyclotron resonance, nuclear and electron spin resonance. For some comments on N. Stone's efforts on nuclear orientation, see ESN 30-2:88 and 30-9:424 or ONRL Reports C-24-75 and C-24-76.

Department of Theoretical Physics

Professor R.J. Elliott, Dr. G.A. Gehring, Dr. D. ter Haar, Dr. M.C.M. O'Brien, Dr. W.E. Parry, Dr. D.J. Roaf, Dr. R.B. Stinchcombe

Research Program: Studies are made of a wide range of problems associated with the understanding of the properties of condensed matter at various levels. There is work on the fundamental theory of the many-body problem in relation to liquid helium, the electron gas, magnetism, plasmas, etc. There is also interest in providing phenomenological theories to interpret experimental information on electronic, vibrational, and magnetic properties of solids. Work is in progress on the theory of phase transitions and on the properties of disordered crystals.

UNIVERSITY OF ST. ANDREWS

School of Physical Sciences

Staff: Prof. J.F. Allen, Mr. J.G.M. Armitage, Drs. P.W.F. Gribbon & D.M. Finlayson, Mr. D. McCall

Research Program: In He II, energy dissipation in film flow between T and 10 mK, above 1 K by mechanical oscillation through resonant inertial oscillation. In superconductivity, generation of heat flow by flux motion in Type II superconductors.
Low temperature electron scattering processes are being investigated by measurements of magnetoresistance and its associated effects. Thermal conductivity measurements on alloys and polymers are being extended to temperatures below 1 K. Magnetic fields up

to 8 T are obtained from superconducting solenoids, and several cryostats cover the temperature range down to 1 K. The range is extended to 50 mK by means of a Harwell dilution refrigerator. SQUIDS are being employed to measure very small voltages and for the calibration of very low temperatures.

On 31 May 1976, I visited the Low Temperature Physics Group at the University of St. Andrews. This group was the host of the 1966 International Conference on Low Temperature Physics, LT 10, and has a strong international reputation for work on helium, especially helium films. The chairman of the Physics Department, Prof. Jack Allen is the backbone of the group. He, with a student, Mr. Toffs, is currently concerned with some film velocity experiments utilizing very pure ^{4}He. In this work they utilize a "vortex" refrigerator to obtain temperatures of about 0.8 K using ^{4}He only.

Another student, Mr. C. Chou, is investigating flux pinning effects in superconductors and a refrigeration scheme utilizing the superconducting transition. The non-metal transition in the sodium tungsten bronzes as a function of pressure and in Ge as a function of doping are being studied by D.D. Tunstall using NMR. He and a student have just completed a high pressure apparatus which will provide about 7 kbar hydrostatically via helium at 1.3 K. Prof. D. Finlayson is utilizing a SQUID picovoltmeter to measure the transport properties of various metallic alloys in the range of a few tens of mK using an Oxford Instruments dilution refrigerator of the older design.

UNIVERSITY OF SALFORD

Department of Pure and Applied Physics

Group Leader: Prof. R.R. Birss, Dr. B. Yeates, Drs. E.D. Isaac, R.D. Barnard, M.A. Black, D. Fletcher, R. Gerber, M. Gluyas, B.W. James, G.J. Keller, D.G. Lord, N. Morton, D.J. Martin, K.A. McEwen, M.R. Parker, R.J. Potton

Research Program: Emphasis is placed on experiments at very low temperatures and in very high magnetic fields, in which various magnetic phenomena are investigated such as magnetocrystalline anisotropy, magnetostriction, the anisotropy of spontaneous magnetization and magneto-optical effects. This work is complemented by theoretical and computational studies on the magnetization process itself in rare-earth and transition metals and alloys. There is also considerable interest in the investigation of lattice dynamics and transport properties of solids down to liquid helium temperatures, and in this connection properties investigated include thermal expansion, specific heat, elasticities, thermal conductivity, and electrical properties. Also being investigated are the symmetry restrictions imposed on transport and optical properties, the form effect, magnetomechanical effects of various kinds and the behavior of novel magnetoelectric materials.

UNIVERSITY OF SOUTHAMPTON

Department of Electrical Engineering
Group Leader: Professor P. Hammond, Dr. R. Stoll, Dr. B. Weedy and Dr. S. Rigby
Research Program: The shielding effects in superconducting ac machinery, cryogenic electrical transmission lines and low temperature properties of high voltage insulation.

Department of Physics
Group Leaders: Prof. E.W. Lee, Dr. R.G. Scurlock, Drs. B.H. Blott, R.H. Dean, K. Kellner, P.C. Lanchester, D. Melville, I.P. Morton
Research Program: Work on the magnetic and electronic properties of metals, alloys and insulators, mainly in the range 2 K to 300 K, including; measurement of magnetization, magnetostriction and anisotropy, especially in pulsed fields up to 40 T and in steady fields up to 10 T provided by a superconducting magnet; anisotropy and magneto-elastic constants of single crystals; magnetostriction of antiferromagnets; studies of permanent magnet materials; neutron diffraction studies using elastic and inelastic scattering carried out at Harwell and Grenoble; a combination of nuclear magnetic resonance and Mössbauer effect to study hyperfine interactions in ordered magnetic materials. Measurement of thermal conductivity, thermal expansion and magneto-electric effects in paramagnetic insulators; studies of phase transitions and critical phenomena in ordered magnetic materials.

UNIVERSITY OF STRATHCLYDE

Department of Applied Physics
Dr. G.B. Donaldson
Research Program: The study and utilization of thin-film dc superconducting quantum interference devices.

Donaldson arrived at Strathclyde in 1975 from the University of California at Berkeley. He worked with Prof. J. Clarke on noise in thin-film SQUIDs and would like to continue the effort.

UNIVERSITY OF SUSSEX

School of Mathematical and Physical Sciences
Laboratory Director: Prof. D.F. Brewer, Drs. D.S. Betts, C.B.P. Finn, A.D.C. Grassie, J.W. Loram, M.G. Richards, M. Springford, A.L. Thomson, K. Thompson and W.S. Truscott
Research Program: Properties of superfluid ^{3}He and ^{4}He, including adsorbed films. Thinfilm superconductivity and properties of vortices in superconductors. The properties of dilute metallic alloys, including specific heat, magnetization and resistivity.

Exchange interaction in solid ^{3}He and ^{3}He-^{4}He mixtures. Fermi surface studies. Paramagnetism. Development of very low temperature techniques, including helium dilution refrigeration and thermometry, the Pomeranchuk effect, and nuclear cooling.

Theoretical Staff: Drs. G. Barton, P.G. Dawber, A.J. Leggett, M.A. Moore, J.S. Plaskett, R.E. Turner, M.J. Wilford

Research Program: Solid state physics research is carried out in many fields. Groups are active in the following topics: electronic structure of alloys and of defects in crystals; optical properties of defects, theory of scattering from magnetic and nonmagnetic impurities in insulators, metals and dilute alloys, conductivity of amorphous semiconductors; macroscopic quantum phenomena in superfluids and superconductors, theory of liquid and solid helium, including the new phases of liquid ^{3}He; phase transitions; mathematical and conceptual problems in the foundations of statistical mechanics and quantum mechanics; and quantum electrodynamics near interfaces.

I visited the University of Sussex on 23 July and spoke with Drs. L. Thompson, D. Betts and A.J. Leggett about the ultralow temperature research program there. This program has been funded by the SRC at about £40,000/year but on a year to year basis--no long range research plan has been funded. The first experiments were on surface-modified Pomaranchuk cooling which was reported at the Institute of Physics' Manchester meeting last January (see ESN 30-4:176 and ONRL Report C-7-76 March 76). Since that time Prof. D. Brewer and Drs. Thompson, Betts, and W. Truscott and Mr. Saunders have developed a nuclear adiabatic demagnetization stage below another dilution refrigerator which is capable of several hours of operation near 1 mK incorporating ^{60}Co x-ray and Pt NMR thermometers. This apparatus is described in the "Study Conference on Nuclear Orientation at Oxford," ONRL Report C-24-76 (Sept. 1976).

The present plans are to do flow experiments on the superfluid phases of ^{3}He. These experiments will utilize a commercially available material developed for biological filtration with uniform pores of diameters down to 0.5 μm. These experiments are slow, so there may be some NMR experiments during the early stages.

Sussex has magnificent theoretical support because of Leggett and Moore. However, the former will be in Africa the first semester of 1976-77 and the latter has just assumed a professorship at Manchester University (at a very young age) and is shifting his interest to polymers.

UNIVERSITY COLLEGE OF NORTH WALES

School of Physical and Molecular Sciences
Dr. D. Caroline and J.C.A. van der Sluijs
Research Program: Light scattering near the critical point of ^3He and the Kapitza boundary conductance of the noble metals.

UNIVERSITY OF WALES

Department of Applied Mathematics
Professor H.N.V. Temperley
The theory of classical and quantum liquids.

UNIVERSITY OF WARWICK

Department of Engineering
Group Leader: Professor J.A. Shercliff, Dr. R.G. Rodes, Dr. D.K. Bowan
Research Program: The electronic behavior of superconducting materials, in particular the ac losses, magnetic levitation of high speed vehicles by superconducting solenoids, and the deformation behavior of superconductors.

THE NEW UNIVERSITY OF ULSTER

School of Physical Sciences
Dr. D.G. Walmsley
Research Program: Electrodynamic behavior of type II superconductors in the mixed state, particular phenomena in geometries where transportcurrents flow parallel to an applied magnetic field. These include Lorentz-force-free magnetic fields, current-induced paramagnetism and the possibility of mutual cutting of fluxlines. Inelastic electron tunnelling applied to the investigation of spectra of organic impurity dopants in thin film superconducting sandwiches. The propagation and interactions of monochromatic phonons in solids studied by phonons generated and detected in thin film superconductors.

PRESTON POLYTECHNIC

Division of Physics
Group Leader: Dr. E. Webster, Mr. P.R. Bissell, Dr. P.A. Bates
Research Program: Investigation of solid state and superconducting devices. Optical and electrical properties of solid and thin film II-VI semiconductors.

Section II. This section deals with Continental institutions. The material makes no pretension to be complete, but is only a reflection of personal observations I was able to make.

Belgium

The Catholic University of Louvain, Heverlee
The use of low temperatures by Dr. R. Coussement, L. Vanneste and coworkers on hyperfine interactions of nuclei at low temperatures was briefly described in ONRL Conference Reports C-24-75 (Dec. 1975) and C-24-76 (Sept. 1976).

Finland

Helsinki University of Technology, Otaniemi
The group at Otaniemi under Professor O.V. Lounasmaa is one of the world's finest ultralow temperature research groups. I have briefly commented on their program in ONRL-Conference Reports C-22-75 (Dec., 1975) and C-7-76 (March, 1976). They have a nuclear demagnetization cryostat capable of temperatures of 1 mK or less and are using this apparatus to study the superfluid phases of ^{3}He. The work in Helsinki has had some spin-offs of commercial cryogenic instrumentation.

University of Turku, Turku
I visited the laboratory at Turku whose leader, Professor V. Hovi, is interested in the cryogenic properties of the halides. Specific heat, NMR, magnetic and optical measurements are being made on these systems.

France

Centre de Recherches sur les Tres Basses Temperature
CNRS, Grenoble
Elements of the research program were covered in ESN 30:7-328 (1976) and ESN 30:7-307 (1976). This laboratory, especially because of the collaboration with the Max-Planck Institut, will likely lead the world in ultralow temperature capabilities in the near future. G. Frossati's new heat exchangers for ^{3}He circulating dilution refrigerators are especially impressive.

University Paris-Sud, Orsay
From E.J.A. Varoquaux's presentation at the Manchester Solid State meeting, I gather the temperature work at Orsay has shifted to a study of the superfluid phases of ^{3}He [see ONRL Conference Report C-7-76 (March 1976)].

Germany

The Free University of Berlin
On two occasions I reported on the low temperature nuclear orientation work by Dr. W. Brewer and coworkers--ONRL Conference Reports C-24-75 (Dec., 1975) and C-24-76 (Sept. 1976).

Fritz-Haber-Institut, Berlin
Dr. G. Klipping and coworkers are concerned with ac losses due to flux jumping for the range of 9-100 Hz in superconducting Nb-Ti-Zr alloys.

University of Köln, (Cologne)
Drs. D. Wohlleben, A.C. Mota and R.F. Hoyt have joined the Physical Institute from the University of California at San Diego, La Jolla. They bring with them a strong and active interest in low temperature physics, especially in superconductivity. They hope to do some work at ultralow temperatures, possibly in collaboration with Jülich.

Institut für Festkörperforschung der Kernforschungsanlage, Jülich
The low temperature research is now directed by Dr. F. Poebell, who is interested in the transport properties near the superfluid transition in ^{4}He and ^{3}He - ^{4}He solutions. There is continuing strong interest in superconductivity and a growing interest in ultralow temperatures at Jülich.

An excellent review of the field of applied superconductivity in W. Germany was recently prepared by R. Hein, ONRL Report R-4-76 (March 1976), and in a shortened format, ESN 30:4-173 (1976). Most of this work is at Karlsruhre and Siemens in Erlangen.

Ireland

University College, Cork
P.T. Sikora has been collaborating with J.P. Charlesworth at AERE Harwell on a study of the 50-Hz losses in filamentary Nb_3Sn wires produced at Harwell.

Israel

Tel-Aviv University
A new group at Tel-Aviv, D. Abraham, S. Altervitz and R. Rosenblum, are interested in the critical current densities in superconducting films. They have been studying granular $Al-Al_2O_3$ films.

Italy

Università di Genova
The low temperature physics program on the superconductivity, magnetism and transport properties by Professor C. Rizzuto was active when I visited in February 1976, though the situation in Italy was darkening economically and in the Universities [see ESN 30:4-155 (1976)].

Università de Rome
The research program in Rome was described in ESN 30:4-180 (1976).

Comitato Nzionale per L'Energie Nucleare (CNEN)
Laboratori Nazionali, Frascati
The research program in Frascati was described in ESN 30:4-179 (1976). Since that time the CNEN and the Instituto Nationale de Fisica Nucleare (INFN) have divided the laboratory as mentioned in the article. It appears unlikely that any more work will be done on ion mobility in superfluid helium there.

Netherlands

Delft University of Technology
Professor J.M. Goldschvartz and coworkers are carrying out a program on He II in a charcoal-pumped helium bath whose ultimate temperature is 0.7 K.

Eindhoven University of Technology
Dr. A. Th. A.M. de Waele and coworkers have a

program on ^{3}He circulating dilution refrigerators with multiple mixing chambers. [see ESN 30:7-307 (1976)].

Kamerlingh Onnes Laboratorium, Leiden
In this Laboratory, undoubtedly the most famous one for low temperature in the world, there have been many changes in the past couple of years. Professor C.J. Gorter has begun retirement and Professor Taconis has become Director of this laboratory and the famous Leiden technicans school. Dr. G.J. van den Berg retired this year and his interest in dilute magnetic alloys will be carried on by Dr. J.A. Mydosh, an American who has spent several years in Jülich, and Dr. G.Y. Nieuwenhuys. Dr. R. de Bruyn Ouboter is continuing his work on ^{4}He circulating dilution refrigerators, and Professor W.J. Huiskamp has an impressive research program on hyperfine fields of oriented nuclei. Most other members of the staff are continuing the same programs as in 1973.

University of Nijmegen
Professor F. Mueller, formerly of Argonne National Laboratory, has joined Professor A.R. de Vroomen and P.R. Wyder at Nijmegen. The program and some novel work being done here are described in ESN 30:9-428 (1976).
Nijmegen has a large (~ 15.0-T) Bitter solenoid with an unusual running cycle. Ice is produced during 14-16 hours to provide cooling during the few hours run of the solenoid.

Switzerland

Centre Etude Recherche Nucléare, Geneva
Dr. T.O. Niinikoski has put together a couple of large throughput ^{3}He circulating dilution refrigerators capable of cooling target materials to about 14 mK. He has developed a refrigerator design based on some simple-to-use equations. [see ESN 30:7-328 (1976)].

Finally, I will mention that a survey of small scale applications of superconductivity has been compiled for all nations of the world in conjunction with the NATO-sponsored meeting in Berlin, in September 1976. This survey should provide an up-to-date directory for the area of superconductivity. For this reason I have emphasized the refrigeration and ultralow temperature components in this report.